JET PROPULSION LABORATORY INTEROFFICE MEMORANDUM

July 22, 2005

TO: D. Morris

FROM: A. Andujo/S. Guduru /E. Hampton/J. Retana

SUBJECT: 2005 DSS-66 and DSS-46 Closure Impact Study

Background

The Resource Analysis Team has completed a special study to analyze the ability of the DSN to provide support to the current users of the 26 Meter subnet. In an effort to reduce cost throughout the DSN, JPL and Deep Space Mission Services are considering retiring the 26 Meter antenna network. We have been tasked to analyze the impact of these potential closures to other DSN resources as well as the users of the DSN, specifically S-Band users. This study focuses on the potential closure of the DSS-66 and DSS-46 antennas individually and together from February 27, 2006 through December 31, 2008 while assuming that DSS-16 is closed. Also analyzed in each scenario is the possible upgrading of the 34 Meter HEF subnet with an S-Band uplink. This study is a follow up to a previous study done to analyze the impact of decommissioning the DSS-16 antenna.

Summary of Results

The effect of the DSS-66 decommissioning during the period analyzed results in an increase to unsupportable time for some 26 Meter subnet users. The results of decommissioning DSS-66 are mixed in that some missions are unaffected, but others are deeply impacted. Those missions impacted are ACE, SOHO and WIND due to their predominantly Northern hemisphere view during GSFC daytime hours and from heavy loading at the 34BWG1 subnet and DSS-27 during their view. Although supportable time is not reduced as much for other missions the impact will be in an increased difficulty negotiating support time. Canberra antennas, namely DSS-34 and DSS-46 also see an increase to unsupportable time throughout this period due to offloading. Decommissioning DSS-66 in this time frame is not recommended.

The effect of the DSS-46 decommissioning during the period analyzed indicates an extreme amount of unsupportable time for ACE, IMAGE, POLR, SOHO and WIND primarily due to the closure of all 26 meter antennas, the overloaded condition of other Canberra antennas and a predominant Southern hemisphere viewperiod for POLAR and IMAGE. Other Canberra antennas, DSS-34 and DSS-45, are already at capacity in this period and do little to assist in offloading DSS-46 requirements; therefore, the addition of an S-Band uplink at DSS-45 would not be as useful since there is already oversubscription at the antenna. The Cluster mission requirement for 3 - 4 antenna arrays will not be completely satisfied. Decommissioning DSS-46 in this time frame is not recommended.

The individual forecast results for DSS-46 decommissioning show that if DSS-66 were operational during this period it would do little to prevent oversubscription at other Canberra antennas due to mission view requirements.

Forecast results also indicate that overall, other subnets such as the 34BWG1 and 34HEF subnets see a large decrease to supportability when all 26 meter antennas are decommissioned. The unsupportable time is concentrated during the daylight viewperiod at Canberra, but because of forecast averaging the supportable time appears high. The 34BWG1 and 34HEF subnet average supportability remains high, above 85% without DSS-66 and DSS-46 in service, but individually the missions in the Sun viewperiod show a drastic reduction in supportable time. If the 26 meter subnet were to close, the addition of S-band uplink on DSS-45 and 65 would be needed. Yet, the analysis does not recommend closing the overseas 26 meter antennas as the 34HEF subnet is already at capacity in the Sun viewperiod. (See Figures 12a-15b)

Assumptions

Analysis was accomplished using the Forecasting and Scheduling Tool for Earth-based Resources (FASTER) forecasting system and the updated mission set database from the February 2005 Resource Allocation Review Board (RARB).

Supports displaced as a result of the DSS-66 and DSS-46 antenna decommissioning are mostly S-Band missions belonging to the SSMO mission set and are mostly reallocated to a resource with S-Band capability such as the 34BWG1 and 34HSB Subnet. In some cases some SOHO support was moved to the 34HEF subnet. (See Figure 1a for a list of missions using the 26 meter subnet and that were moved)

During analysis several factors were considered:

- DSN resources down during the requested time period (See Figures 20 -23)
- DSN provides emergency support that may preempt or interrupt supports scheduled for network users
- DSS – 16 closed throughout this period
- DSS – 27 upgraded with full TT&C (NSP, SLE) with Acquisition Aid and Auto Tracking
- DSS – 27 Setup and Teardown time is unchanged for this study, but may increase due to the change in capability and their use.
- DSS – 66 closed as early as February 27, 2006
- DSS – 46 closed as early as October 2, 2006

The periods selected to remove the DSS-66 and DSS-46 antennas from service was determined by the least amount of events that would be impacted by decommissioning.

Current Key Mission Requirements

- The apogee for both the POLAR and IMAGE missions occur over the Southern hemisphere, because of this DSS-34 and DSS-46 are the primary DSN resources utilized by these missions in order to meet their mission requirements.
- The ACE, CLUSTER II, Geotail, and SOHO missions all utilize the 26 meter subnet in order to meet their mission requirements

- 80% of CLUSTER II's Wide-Band Data (WBD) Opportunities are in the southern hemisphere and require simultaneous tracking support from three to four apertures
- SOHO will be in their Keyhole period in:
    - Weeks 08 through 12 of 2006
    - Weeks 21 through 24 of 2006
    - Weeks 34 through 38 of 2006
    - Weeks 47 through 50 of 2006
    - Weeks 07 through 11 of 2007
    - Weeks 20 through 23 of 2007
    - Weeks 32 through 36 of 2007
    - Weeks 46 through 48 of 2007
    - Weeks 06 through 09 of 2008
    - Weeks 19 through 21 of 2008
    - Weeks 31 through 35 of 2008
    - Weeks 45 through 47 of 2008

- Mars Reconnaissance Orbiter (MRO) is scheduled to launch on August 10, 2005, DSS-16 and DSS-46 support required for launch and initial acquisition.
- Stardust (SDU) Earth Re-entry and Re-Entry support in weeks 01 - 03 of 2006.
- New Horizon (NHPC) is scheduled to launch on January 10, 2006, DSS-46 support required for launch and initial acquisition.
- Stereo Ahead (A) and Behind (B) are scheduled to launch February 11, 2006, DSS-46 support required for launch and initial acquisition. It is expected that the Stereo launch will be moved to April of 2006.
- Space Technology-5 (ST-5) is scheduled to launch on February 28, 2006. DSS-16 and 46 Acquisition Aid support is required for launch, initial acquisition and early operations support for approximately 8 days. The PSLA additionally documents post maneuver and emergency support Acquisition Aid requirements.
- Dawn is scheduled to launch no earlier than June 17, 2006 DSS-46 support required for launch, initial acquisition.
- GOES-O is scheduled to launch no earlier than June 01, 2007, 26 Meter support required for launch, initial acquisition, and early operations support for approximately 21 days.
- NOAA-N Prime (NO19) is scheduled to launch no earlier than March 1, 2008, 26 Meter support required for launch, initial acquisition, and early operations support for approximately 21 days.

Current mission requirements dictate the specific use of DSS-46 and DSS-66, for both nominal activities and critical events. As a result of the 26 meter subnet closure some users may be able to offload support to the 34 meter or 70 meter subnets, but not all missions have this option and offloading creates further contention that the 34 and 70 meter subnets would not be able to absorb without a marked increase in unsupportable time. As the Ulysses mission can only be

supported from Canberra due to its view, it will deeply impact Canberra supportability in this time period when it begins its Nutation phase.
Several Low Earth Polar and Equatorial Orbiting missions rely upon the DSN 26 meter subnet for emergency and backup support (See Figure 1c). These LEO missions are not capable of being supported at other DSN subnets due to the nature of their orbit.

Other major events and downtimes occurring during the study period are listed in the supporting data attached at the end of this study.

Analysis

Individual Missions have experienced mixed results but for the most part the DSS-66 closure is not tolerable for some missions, such as ACE, SOHO and Wind, which see supportable time decrease as low as low as 59%. The closure of DSS-46 also produces increasing amounts of unsupportable time for DSN users as low as 39%. The upgrade of the DSS-27 antenna helps to alleviate this condition, but 2 and 3 antennas decommissioned cannot be overcome with the antenna upgrade. (See Figures 2a - 2b) The following details each mission's results based on forecast data assembled:

ACE: ACE averages 83%supportable time without DSS-66 in service and is further decreased to 68% during SOHO HSO. During the DSS-46 and DSS-66 closure, ACE averages about 76% supportability, which is a low amount considering the minimal mission requirement. (See Figures 3a-3b)

Chandra: Average supportability for Chandra is at 94% due to the DSS-66 and DSS-46 closure as it is primarily supported by the 34BWG1 subnet, although increased utilization of the 34BWG1 subnet will increase negotiation during scheduling. (See Figures 4a-4b)

Cluster II: Cluster supportability averages 96% due to the DSS-66 and DSS-46 closure. However support will be difficult to attain due to its requirement for simultaneous tracking of three to four spacecraft at the same complex. This is severely impacted by the 26 meter subnet closure and will result in the DSN not being able to support the missions' science requirements in Canberra or Madrid, as these closures will reduce the number of antennas. (See Figures 5a-5b)

Geotail: Geotail supportability remains at an average of 99% without DSS-66 and DSS-46 primarily as it has a small requirement and is able to be supported from all DSN subnets except the 34BWG2. In most cases an increase in supportable time is seen due to not contending with DSS-16 utilization. (See Figures 6a-6b)

IMAGE: IMAGE supportability is at 93% as a result of the DSS-66 closure as they are primarily supported from Canberra due to their orbit which limits Northern hemisphere view where supportability falls to an average of 86% when DSS-46 is decommissioned. (See Figures 7a-7b)

INTEGRAL: INTEGRAL supportability remains at 100% after DSS-66 is decommissioned and at 95% when DSS-46 is decommissioned primarily due to its minimal requirements. (See Figures 8a-8b)

Polar: Polar supportability is reduced to 82% when DSS-66 is closed and supportability averages 67% until the end of mission when DSS-46 is decommissioned primarily as it is supported from Canberra due to their orbit which limits Northern hemisphere view. (See Figures 9a-9b)

SOHO: The SOHO mission supportability averages 79% without DSS-66, but without DSS-46 mission supportability falls to an average of 59%. During SOHO "Keyhole" periods supportability drops to 51% without the 26 meter subnet in service. (See Figures 10a-10b)

Wind: Wind supportability is at 57% when both DSS-66 and DSS-46 are decommissioned. Wind is primarily supported by the 34BWG1 subnet and increased utilization of the 34BWG1 subnet does impact the mission. (See Figures 11a-11b)

DSN Maintenance supportability decreases by an average of 16% at the 34BWG1 and 34HEF subnets in all scenarios as a result of the support offloading due to decommissioning the 26 Meter subnet.

Conclusion

Based on forecast data gathered from User Loading Profiles (ULP's) for all active missions, the DSN can provide approximately 84% all of the currently requested support if DSS-66 is decommissioned as early as February 27, 2006. This 84% average does not reflect that some missions specifically ACE, SOHO and WIND spacecraft supportability drop as low as 51% in some periods if DSS-66 is decommissioned.

The forecast for DSS-46 indicates that supportability drops to an average of 74% and would cause certain missions to fail to meet requirements without DSS-16 and DSS-66 in service. The loss of DSS-46 would more severely impact Canberra on the whole as there would be too few antennas to support Southern hemisphere requirements. A mission requesting continuous coverage or multi-spacecraft arrays would cause increased unsupportable time in Canberra. It should also be taken into consideration that missions launching throughout this period and beyond will require Acquisition Aid support currently only provided by the 26 Meter subnet. Future Acquisition Aid usage is detailed in Figure 1b.

The addition of an S-Band uplink at the 34 meter HEF antennas could assist in the offloading of the DSS-66 but would not be sufficient to support the decommissioning of DSS-46, as DSS-45 is already loaded to capacity within the daylight viewperiod. Overall the subnet is already at capacity, and supportability dropped by an average of 11% in the periods where SOHO was added. Additional loading will prove to cause a marked increase to unsupportable hours on the subnet. Therefore, the addition of an S-Band uplink to the 34HEF subnet will not reduce the impact of decommissioning all 26 meter antennas, yet would be necessary to provide a backup uplink capability.

Recommendations

- Based on this study case it is recommended that DSS-66 not be decommissioned earlier than the end of the end of extended mission for SOHO, which at this time is planned for December 31, 2008. With the condition that Acquisition Aid capability is implemented in Madrid.
- It is also recommended that DSS-46 not be decommissioned until the end of mission of most current SSMO missions, specifically the SOHO mission in December 31, 2008. With the condition that Acquisition Aid capability is implemented in Canberra.
- If the entire 26 meter subnet is closed prior to December 31, 2008, then it is recommended that an S-band uplink capability be provided at DSS-45 and 65 to ensure that two antennas at a complex may command the supported spacecraft.
- It is recommended that DSS-27 antenna be upgraded with full TT&C (NSP, SLE) and Acquisition Aid with Auto Tracking as there are still requirements for Acquisition Aid with Auto Tracking at Goldstone. (See previous study discussing the impact of decommissioning the DSS-16 antenna, titled "2005 DSS-16 Decommissioning Impact Study". http://rapweb.jpl.nasa.gov/studies.html)
- Provide at least six months to one year notice before decommissioning any antenna, to allow mission planning to plan.

Supporting Data

Figure 1a: DSN 26 Meter User Mission Set

DSN 26 Meter Mission Set				As of: June 6, 2005
Project	Acronym	Launch or Start	EOPM	EOEM
Geotail	GTL	07/24/92	07/24/95	09/30/06
Wind	WIND	11/01/94	11/01/97	12/31/06
SOHO	SOHO	12/02/95	05/02/98	12/31/08
Polar	POLR	02/22/96	08/23/97	12/31/06
Advance Composition Explorer	ACE	08/25/97	02/01/01	09/30/10
Chandra X-ray Observatory	CHDR	07/23/99	07/24/09	07/24/14
Imager for Magnetopause-to-Aurora Global Exploration	IMAG	03/25/00	05/30/02	09/30/10
Cluster 2 - S/C #2 (Samba)	CLU2	07/16/00	02/15/03	12/31/09
Cluster 2 - S/C #3 (Rumba)	CLU3	07/16/00	02/15/03	12/31/09
Cluster 2 - S/C #1 (Salsa)	CLU1	08/09/00	02/15/03	12/31/09
Cluster 2 - S/C #4 (Tango)	CLU4	08/09/00	02/15/03	12/31/09
International Gamma Ray Astrophysics Lab	INTG	10/17/02	12/18/04	12/31/08

Figure 1b: DSN Acquisition Aid

Project	Launch or Start	Launch Frequency	Initial Acq Complex
GOES-N	06/26/05	S	CAN
Mars Reconnaissance Orbiter	08/10/05	X	CAN or GDS
Venus Express	10/26/05	S	CAN
New Horizons	01/11/06	X	CAN
Space Technology 5	02/28/06	X	CAN
STEREO Ahead	04/11/06	X	CAN
STEREO Behind	04/11/06	X	CAN
GOES-O (date - KSC Launch Sched.)	06/01/06	S	CAN
Dawn	06/17/06	X	MAD
SELENE	02/01/07	S	MAD or GDS
Phoenix	08/03/07	X	GDS
NOAA-N' (pending repairs)	03/01/08	S	MAD
Kepler	06/01/08	X	CAN
Lunar Reconnaissance Orbiter	11/15/08	S	CAN

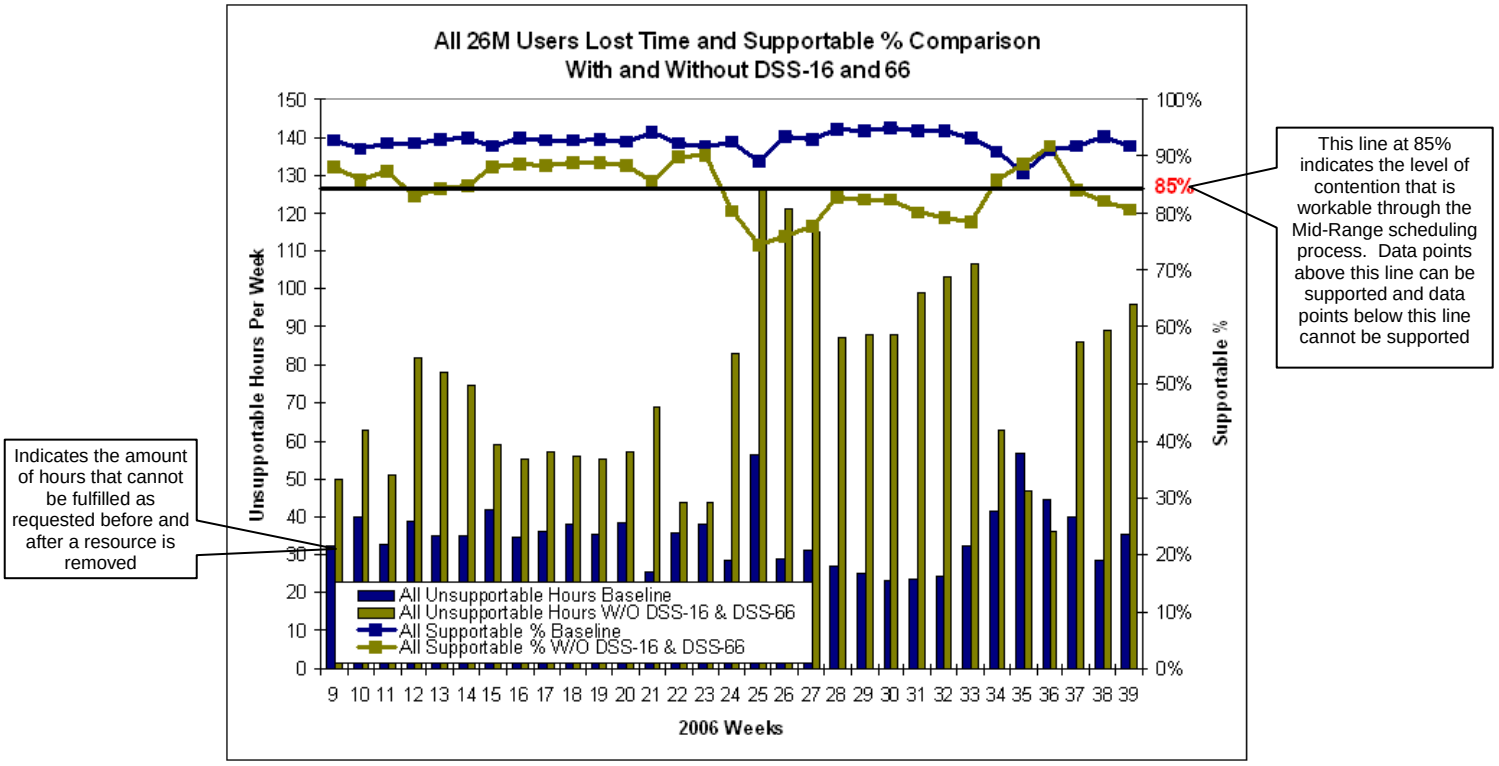
Figure 1c: DSN LEO Emergency Support

Low Earth Orbiting (LEO) Missions

Polar Missions	Support Type	Potential End of Support
Landsat 5 (USGS satellite)	Emergency	9/30/2005
Polar Orbiting Environment Satellites (POES, aka NOAA)	Emergency	6/24/2007
RADARSAT (Also Listed As a Routine Support Mission)	Routine &Backup	9/30/2008
Total Ozone Mapping Spectrometer (TOMS-EP)	Emergency	9/30/2005

Equatorial Missions	Support Type	Potential End of Support
Earth Radiation Budget Satellite (ERBS)	Emergency	9/30/2005
Hubble Space Telescope (HST)	Emergency	4/24/2010
Rossi X-Ray Timing Explorer (XTE)	Emergency	9/30/2010
Tropical Rainfall Measuring Mission (TRMM)	Emergency	9/30/2006
Upper Atmosphere Research Satellite (UARS)	Emergency	9/30/2005

Figure 2a: Impact to All 26 Meter Users Supportable and Unsupportable Hours and Percentage



Note: This chart is designed to illustrate to the reader the increase in unsupportable hours and percentage caused by the DSS-66 and DSS-46 decommissioning. An increase in unsupportable hours causes a failure to meet requirements.

Figure 2b: Impact to All 26 Meter Users Supportable and Unsupportable Hours and Percentage

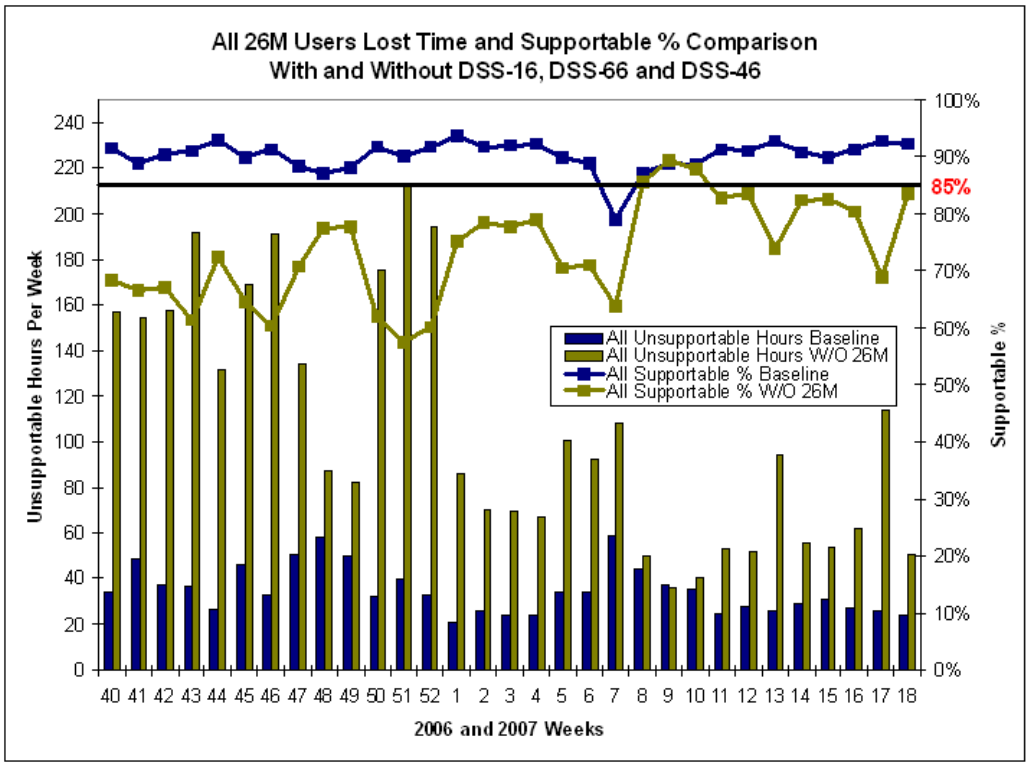


Figure 3a: Impact to ACE Supportable and Unsupportable Hours and Percentage

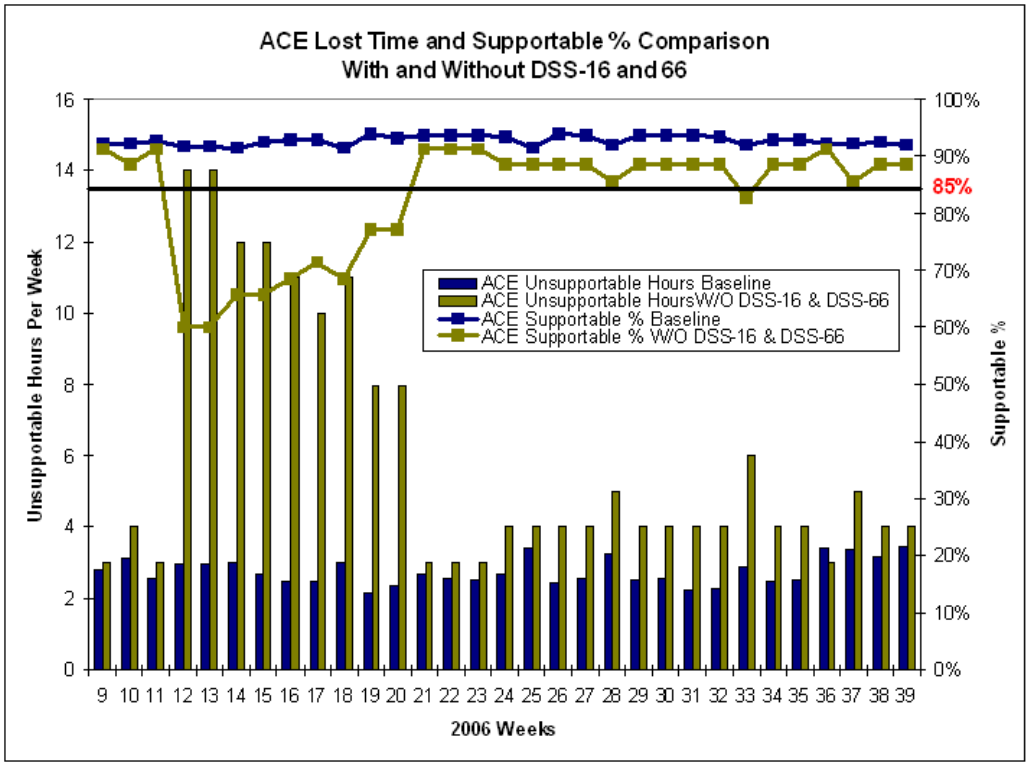


Figure 3b: Impact to ACE Supportable and Unsupportable Hours and Percentage

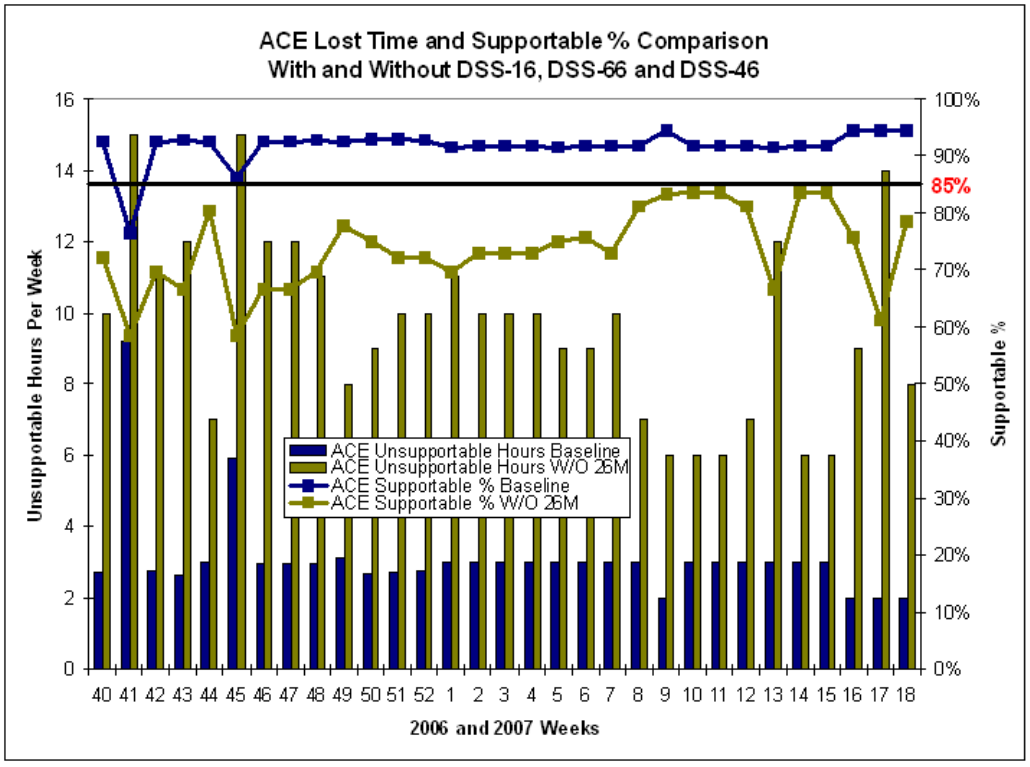


Figure 4a: Impact to Chandra Supportable and Unsupportable Hours and Percentage

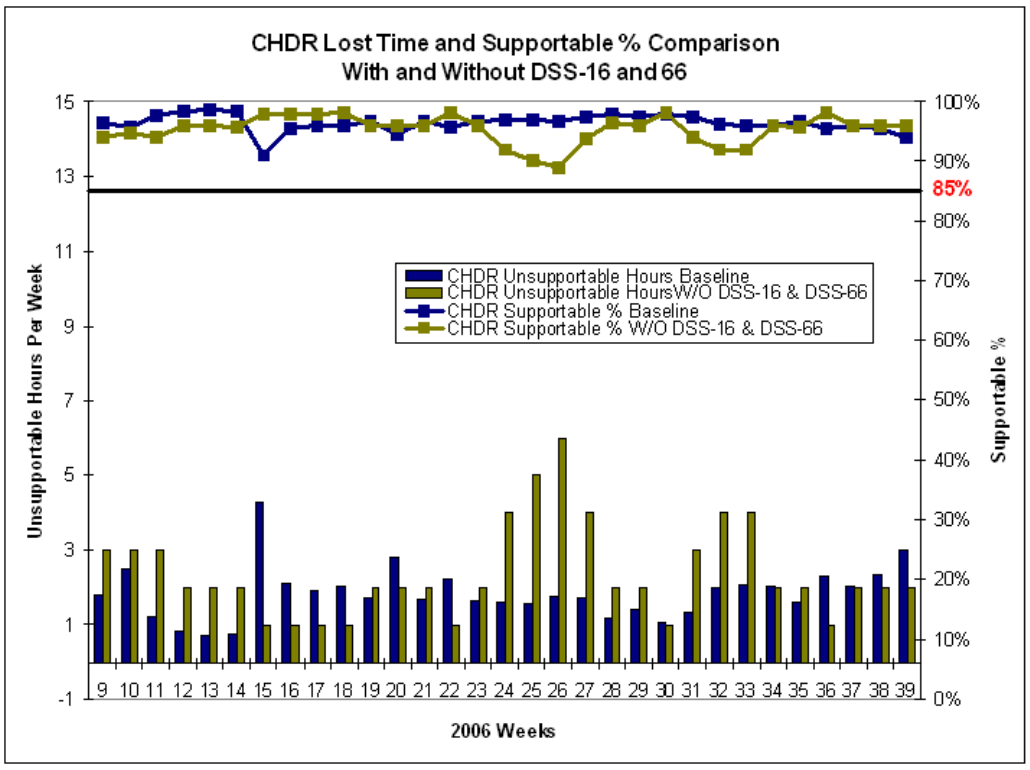


Figure 4b: Impact to Chandra Supportable and Unsupportable Hours and Percentage

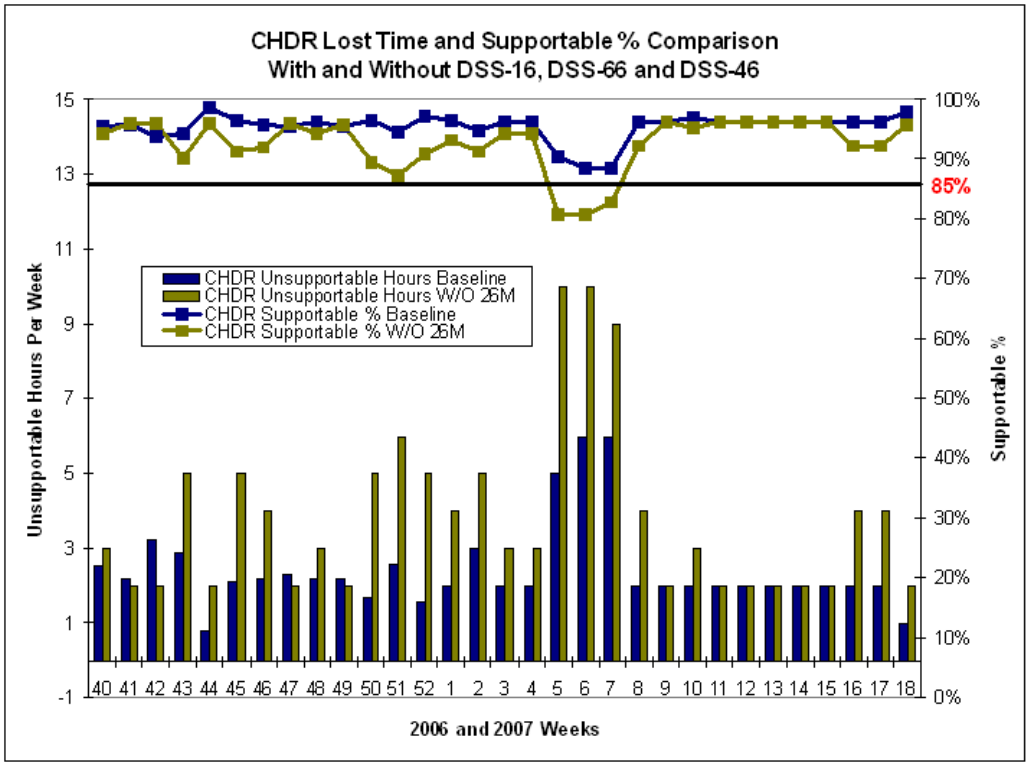


Figure 5a: Impact to Cluster Supportable and Unsupportable Hours and Percentage

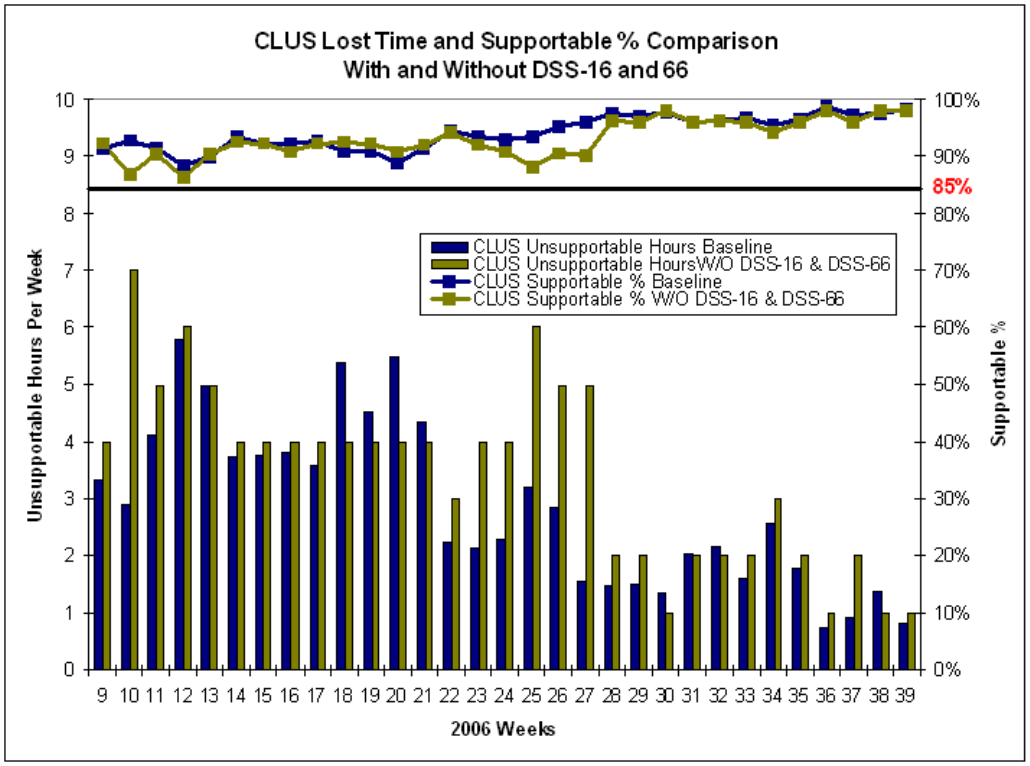


Figure 5b: Impact to CLU Supportable and Unsupportable Hours and Percentage

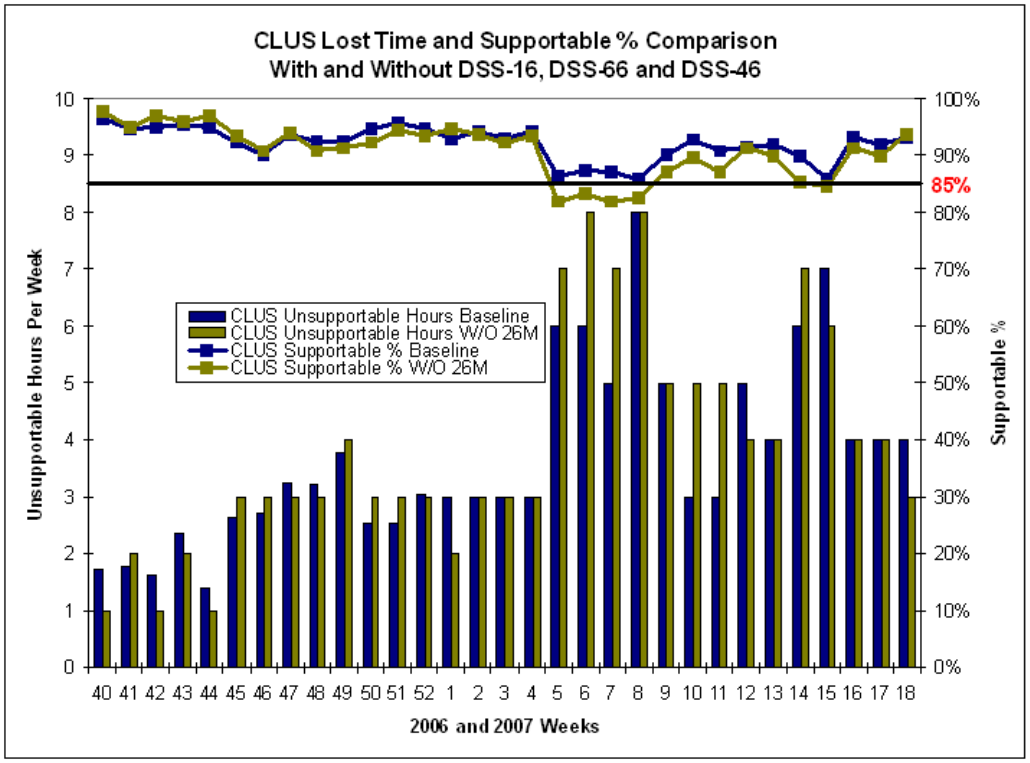


Figure 6a: Impact to Geotail Supportable and Unsupportable Hours and Percentage

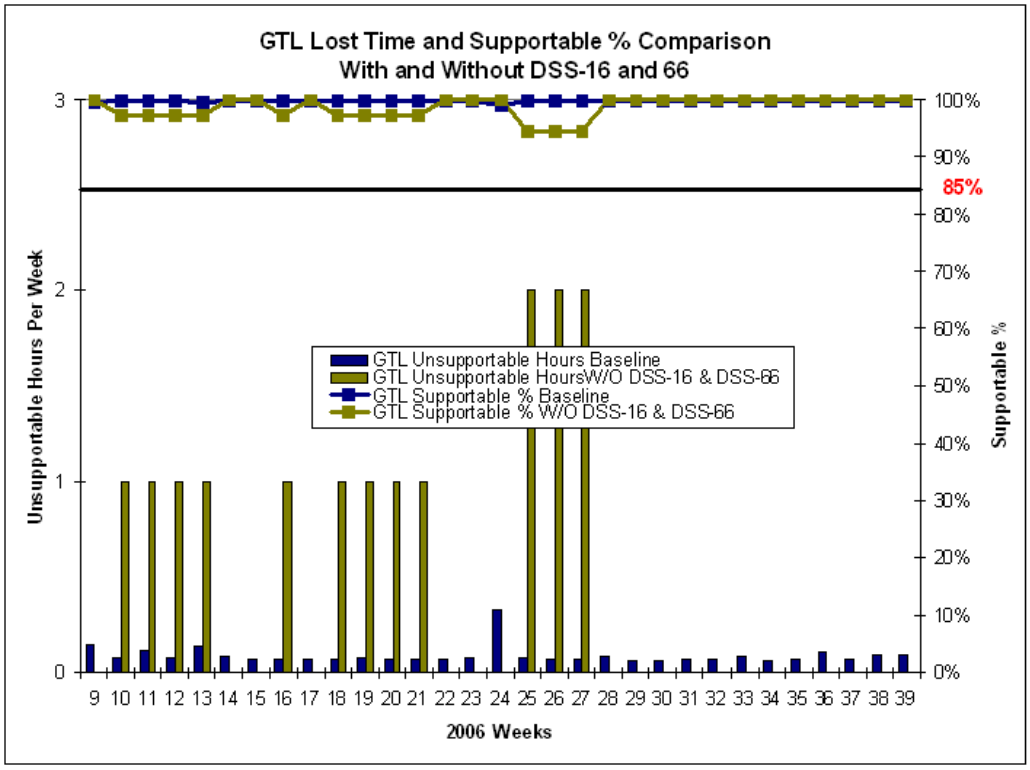


Figure 6b: Impact to Geotail Supportable and Unsupportable Hours and Percentage

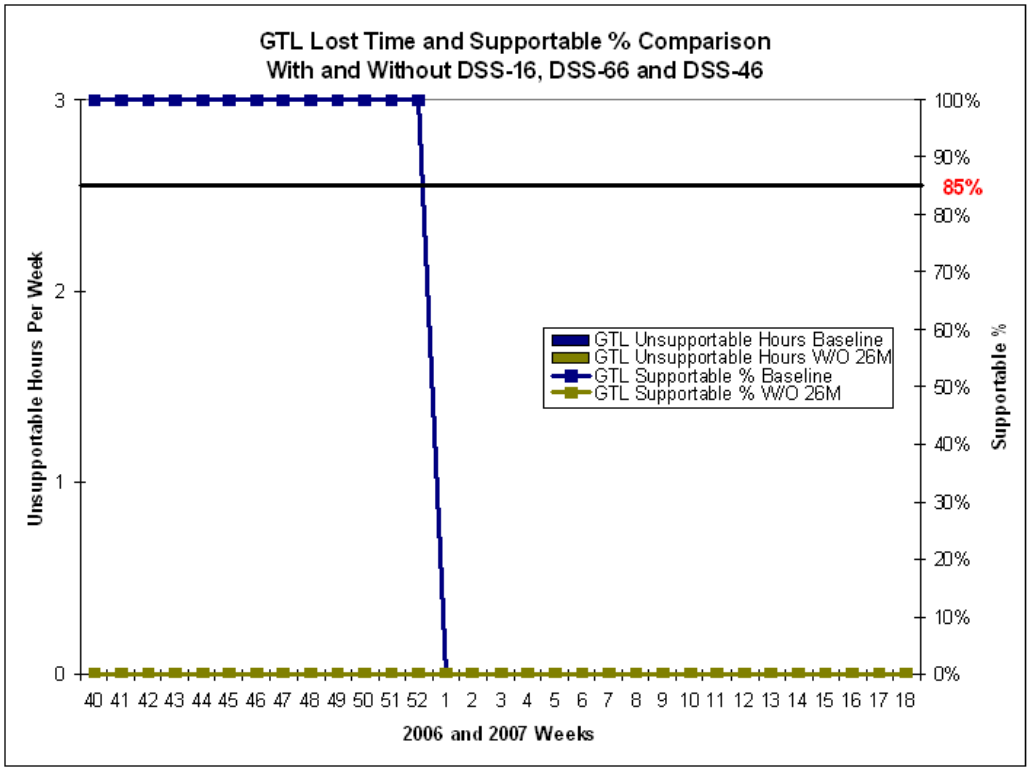


Figure 7a: Impact to IMAGE Supportable and Unsupportable Hours and Percentage

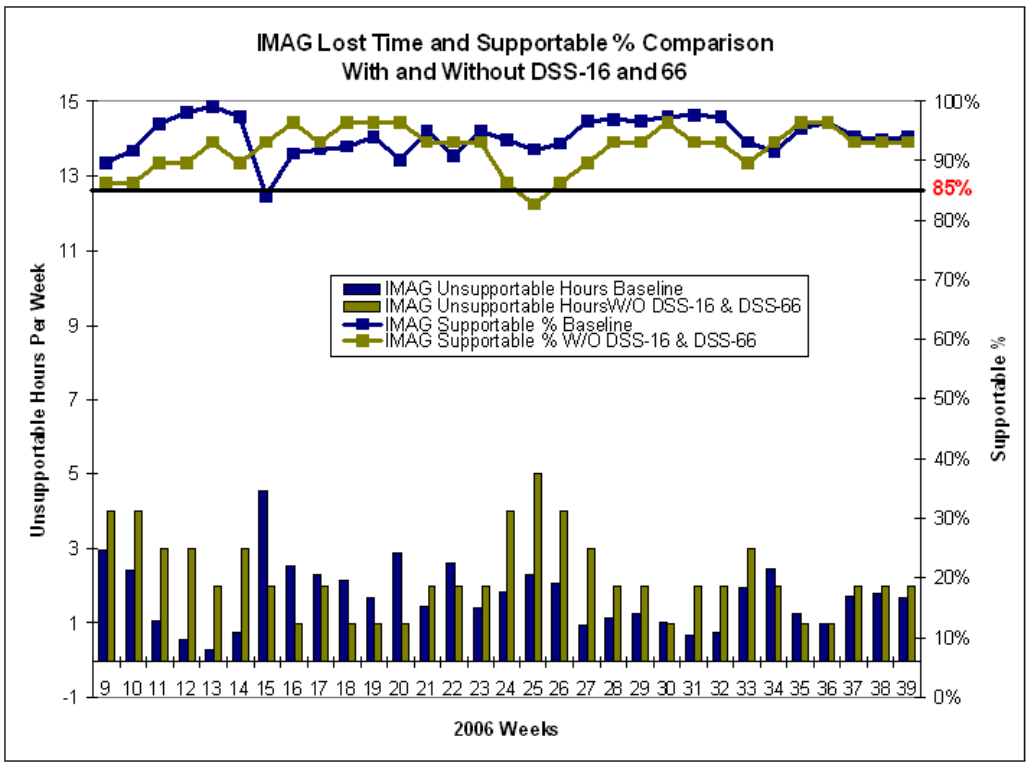


Figure 7b: Impact to IMAGE Supportable and Unsupportable Hours and Percentage

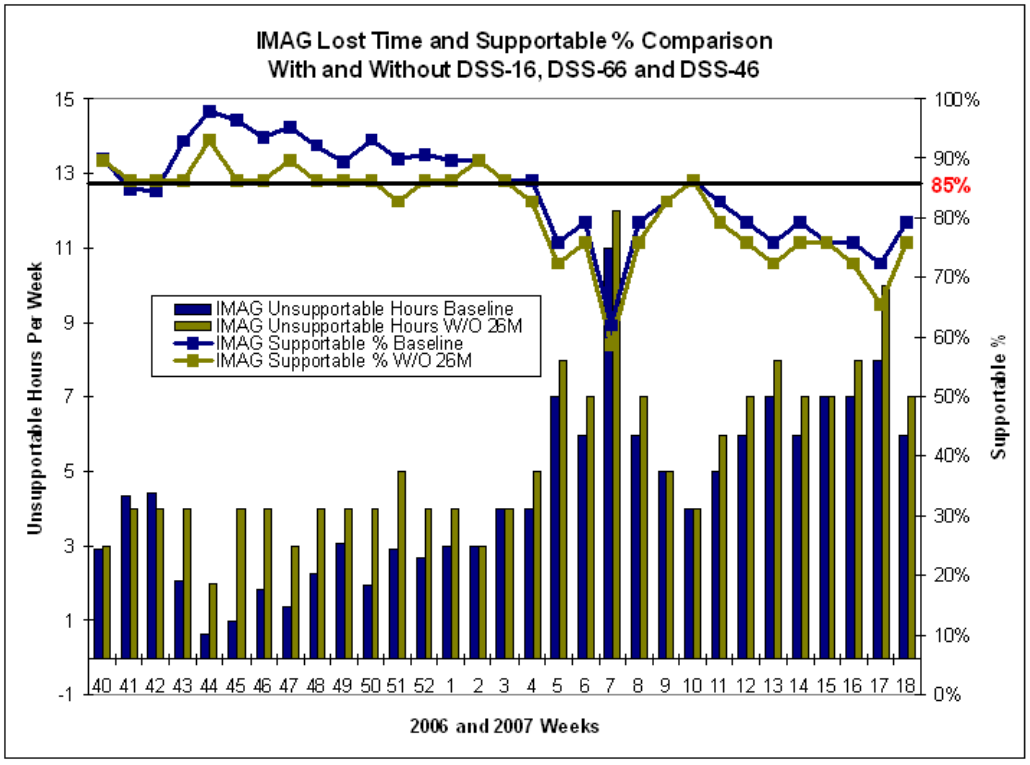


Figure 8a: Impact to INTEGRAL Supportable and Unsupportable Hours and Percentage

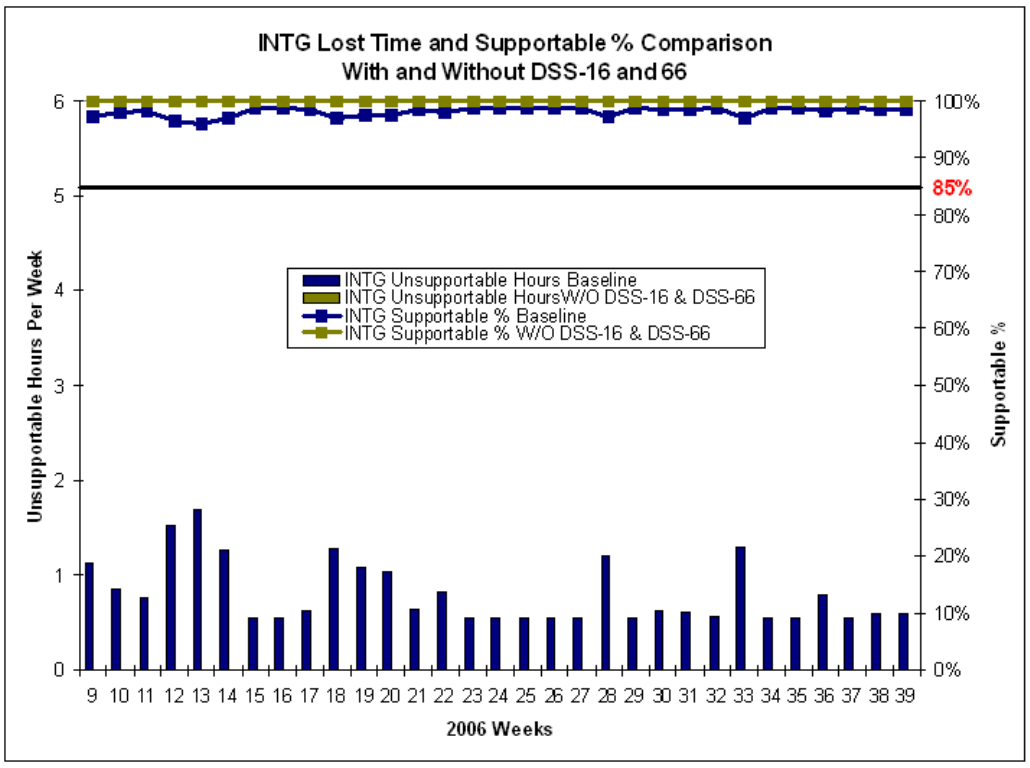


Figure 8b: Impact to INTEGRAL Supportable and Unsupportable Hours and Percentage

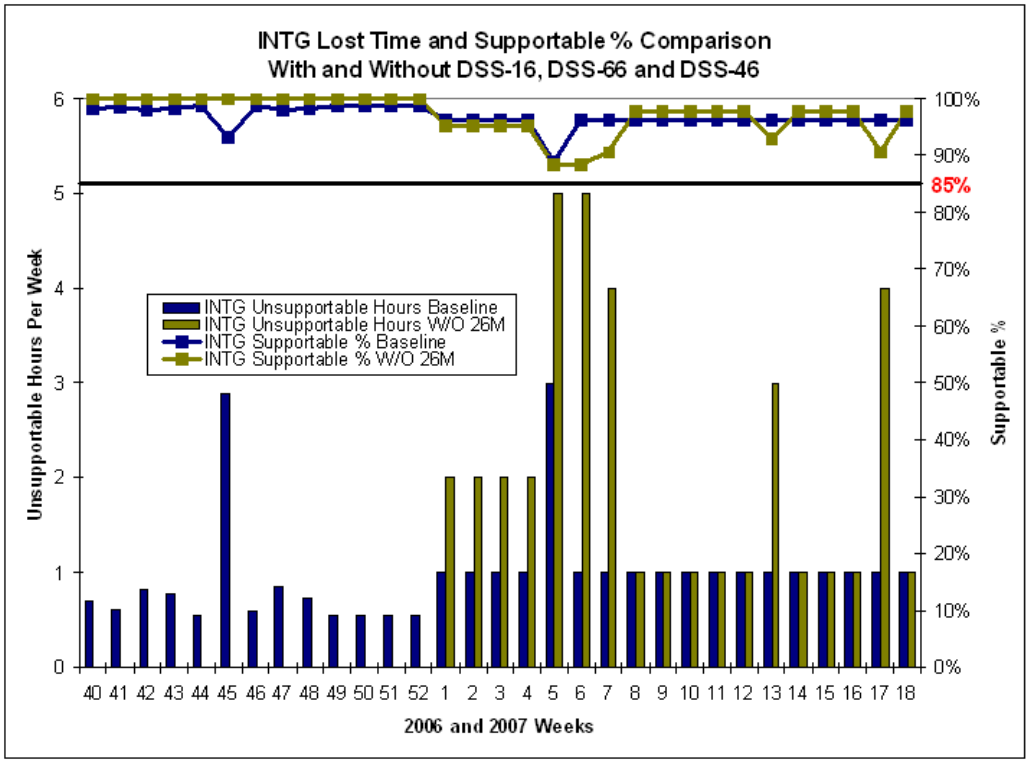


Figure 9a: Impact to POLAR Supportable and Unsupportable Hours and Percentage

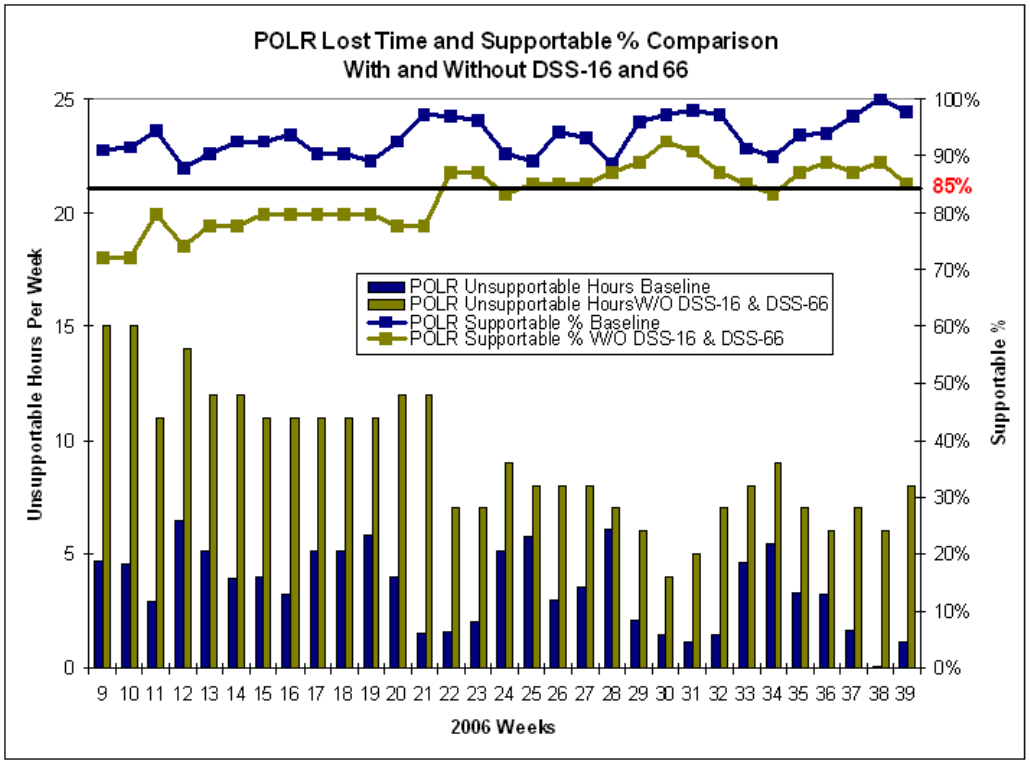


Figure 9b: Impact to POLAR Supportable and Unsupportable Hours and Percentage

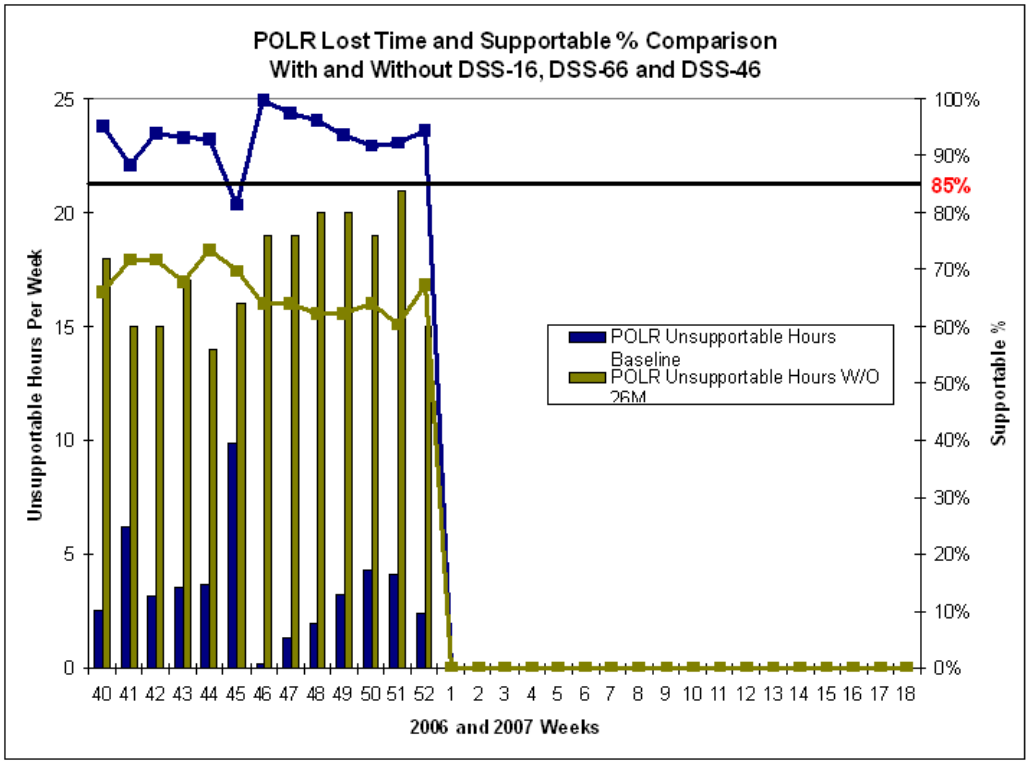


Figure10a: Impact to SOHO Supportable and Unsupportable Hours and Percentage

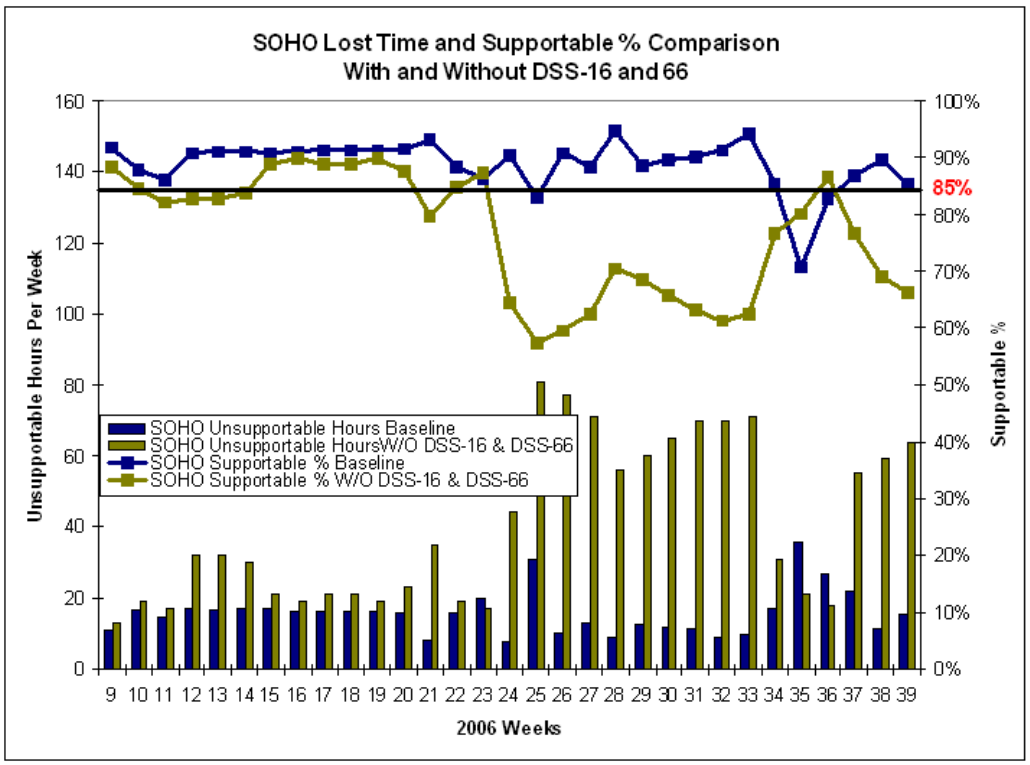


Figure10b: Impact to SOHO Supportable and Unsupportable Hours and Percentage

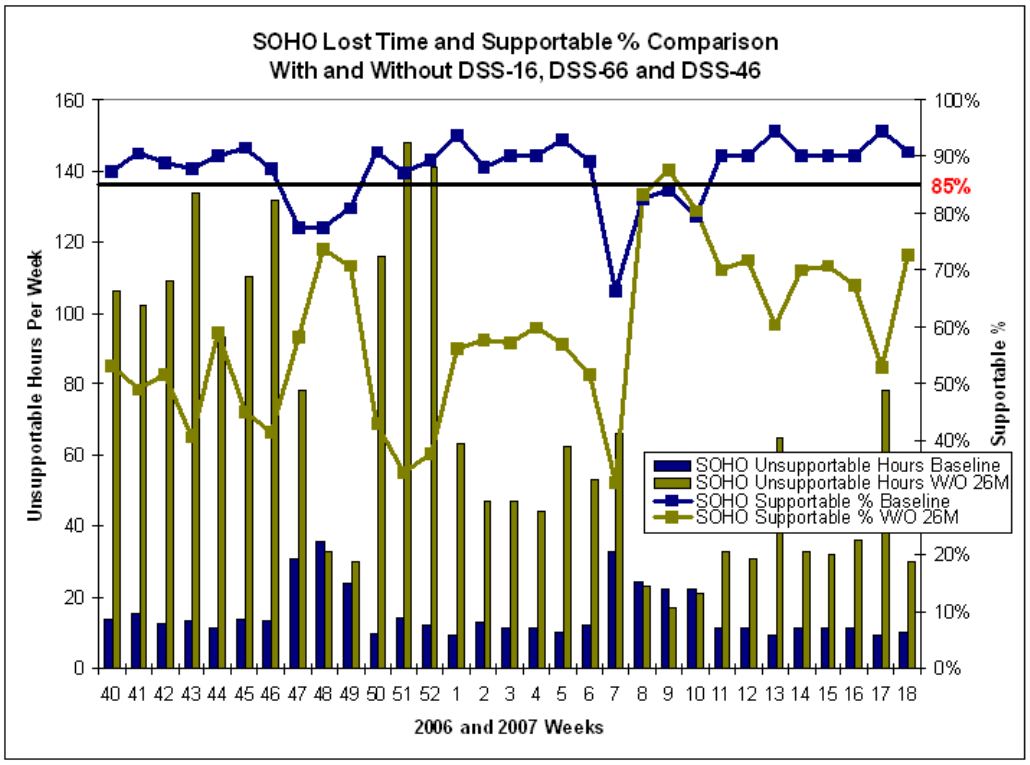


Figure11a: Impact to Wind Supportable and Unsupportable Hours and Percentage

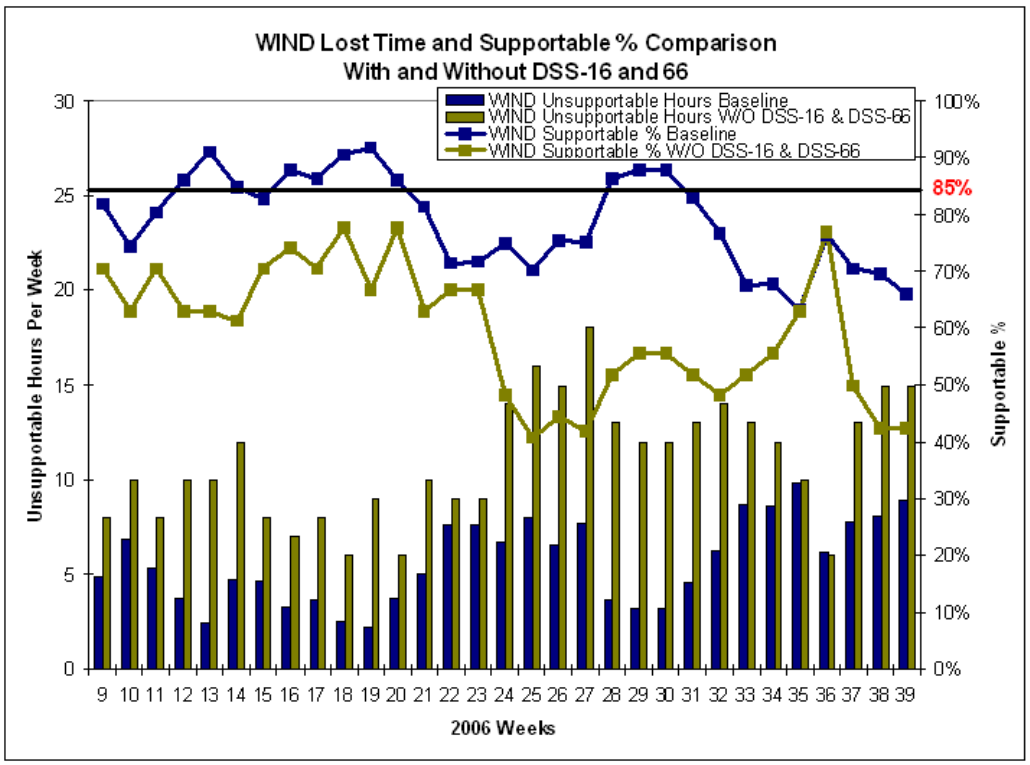


Figure11b: Impact to Wind Supportable and Unsupportable Hours and Percentage

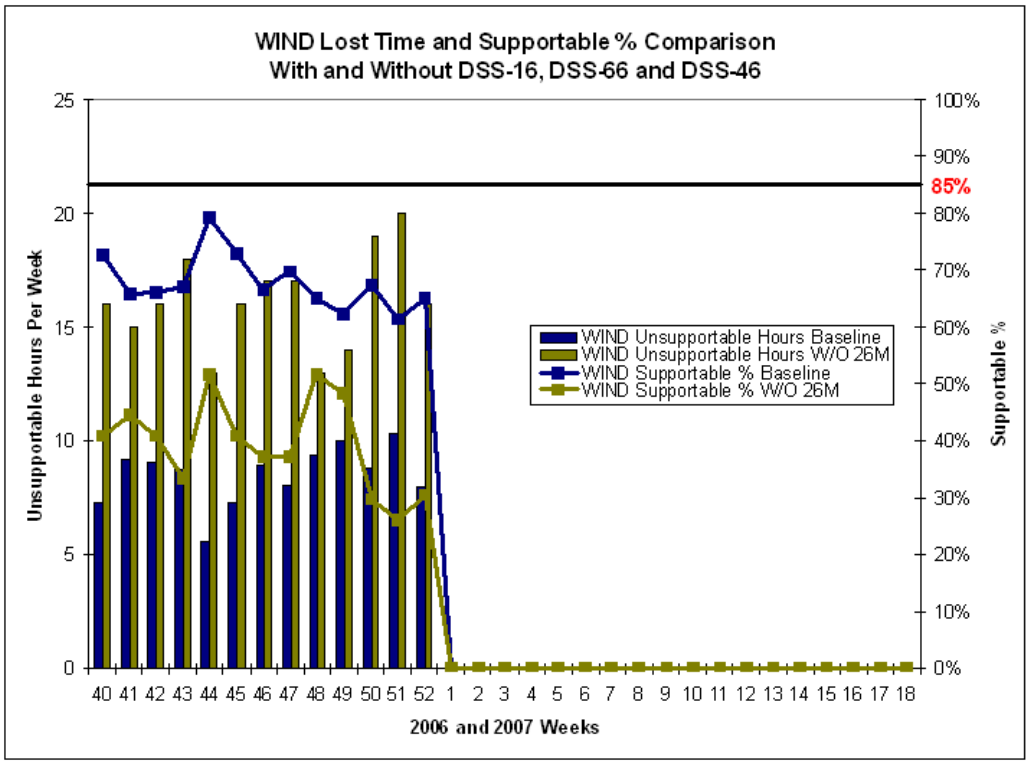


Figure 12a: Impact to 34HEF Supportable and Requested Time

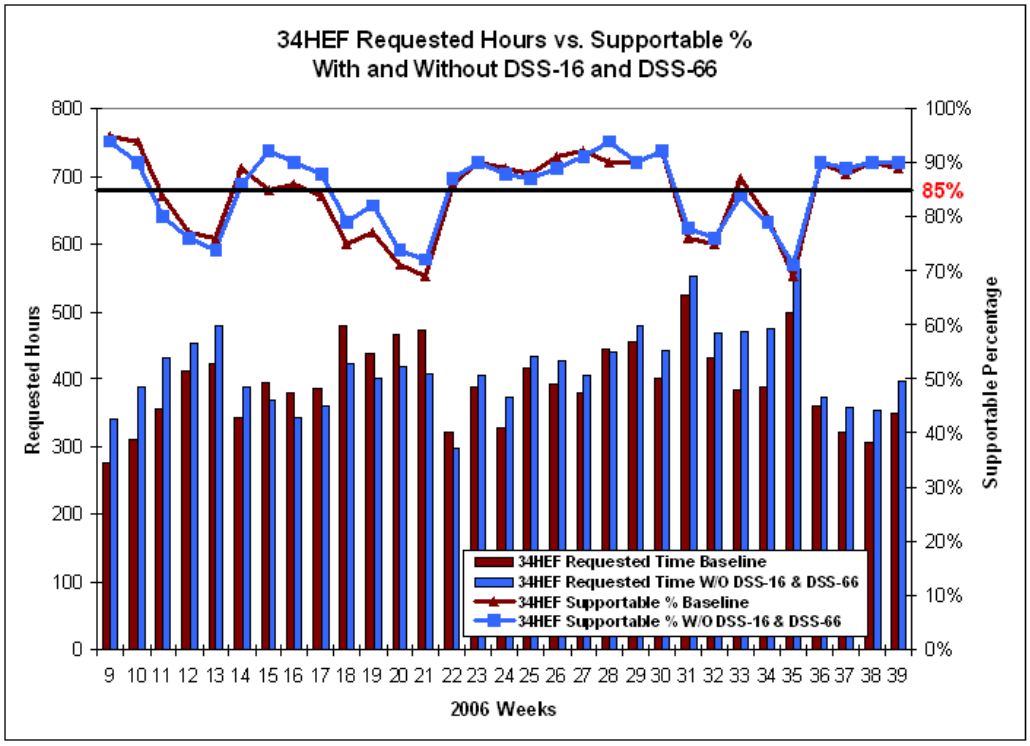


Figure 12b: Impact to 34HEF Supportable and Requested Time

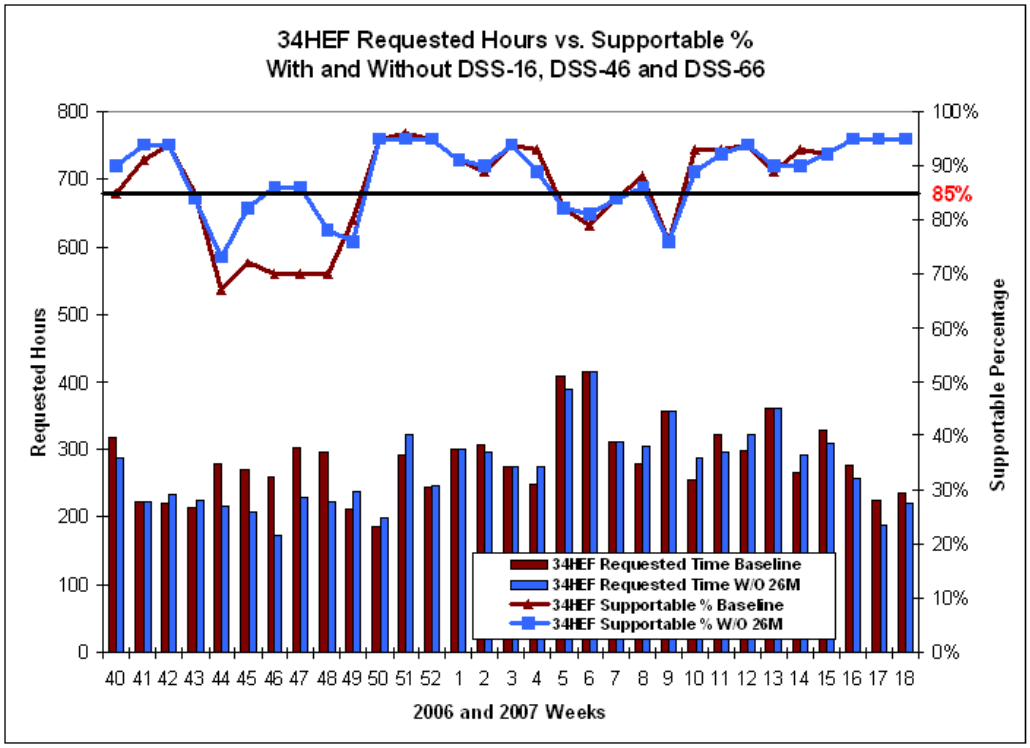


Figure 13a: Impact to 34BWG1 Supportable and Requested Time

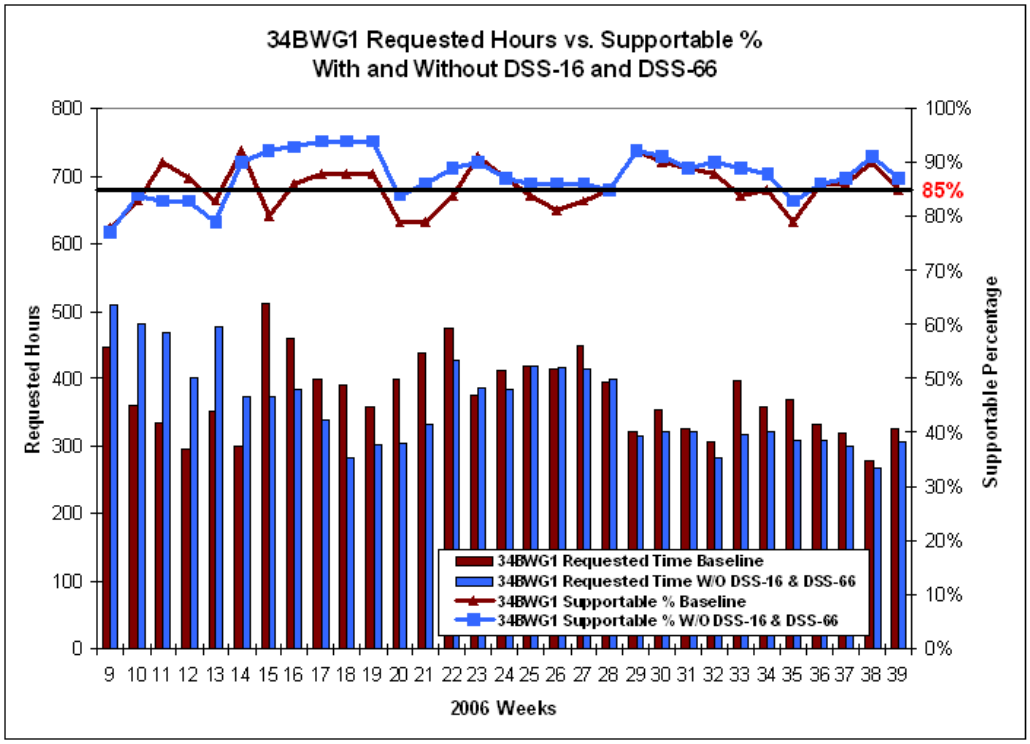


Figure 13b: Impact to 34BWG1 Supportable and Requested Time

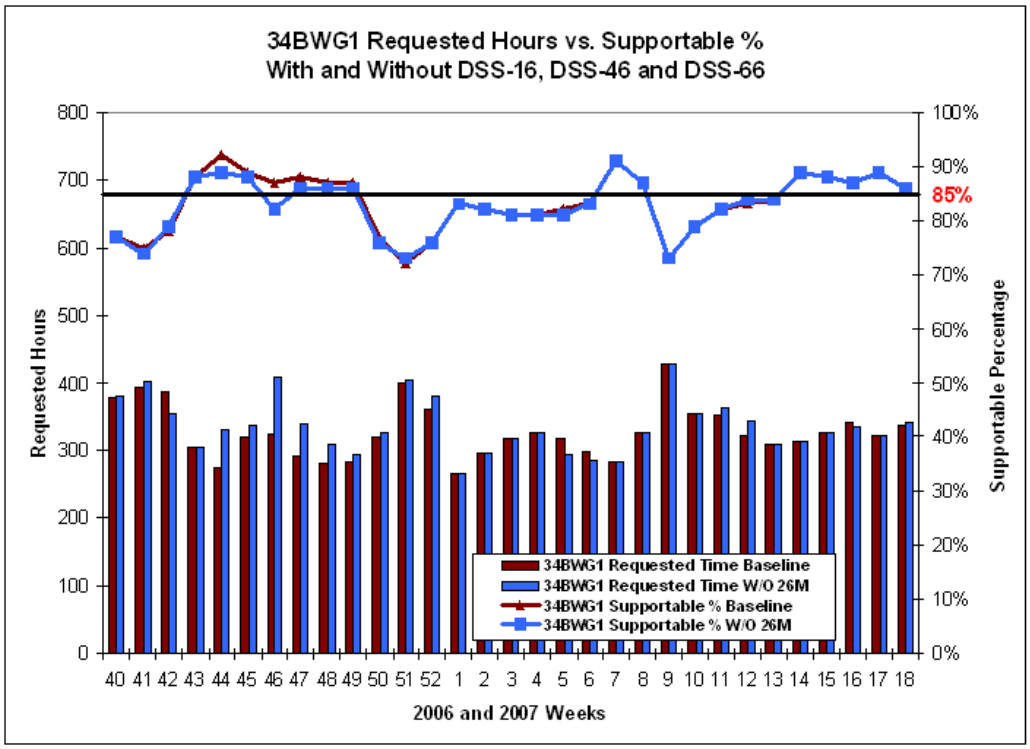


Figure 14a: Impact to 34HSB Supportable and Requested Time

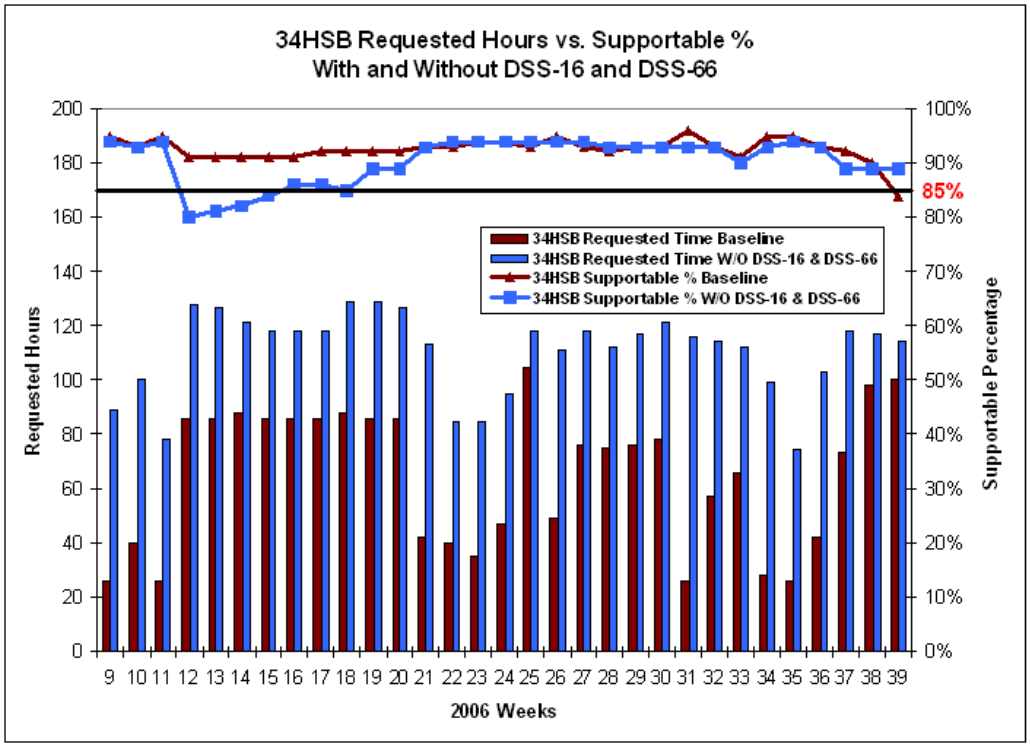


Figure 14b: Impact to 34HSB Supportable and Requested Time

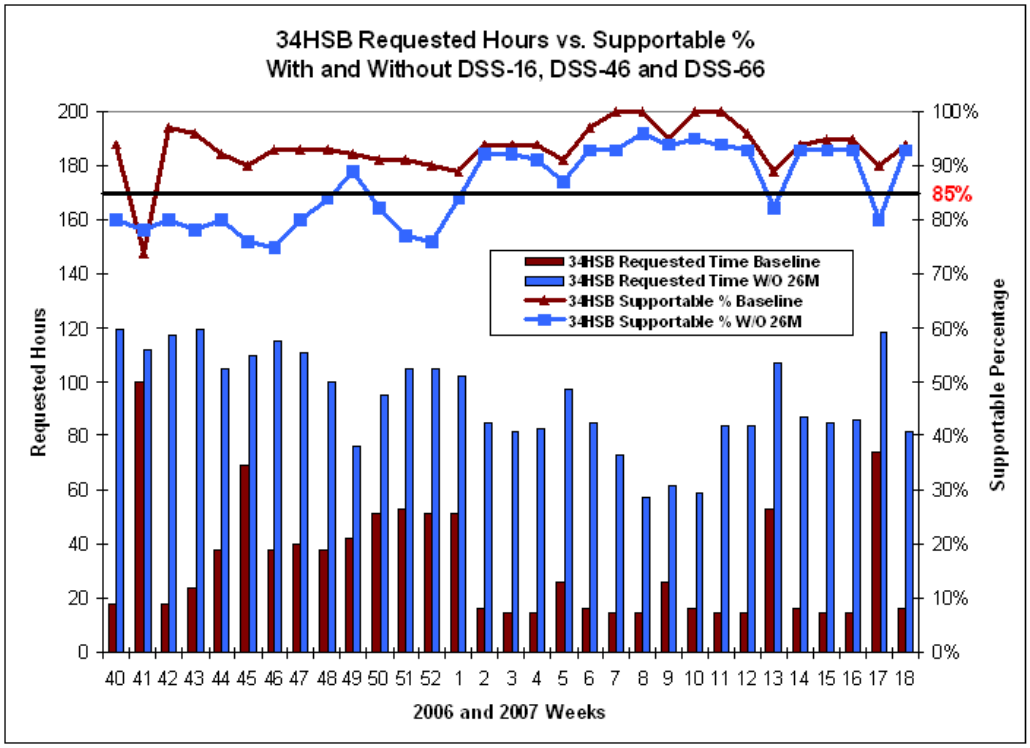


Figure 15a: Impact to 26M Supportable and Requested Time

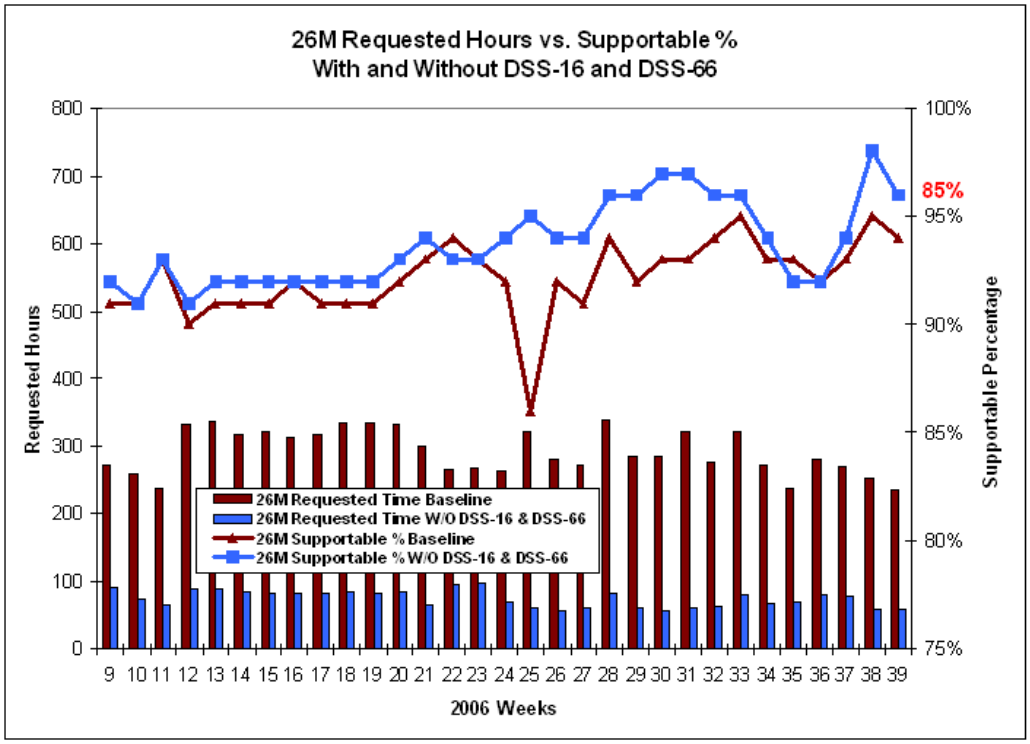


Figure 15b: Impact to 26M Supportable and Requested Time

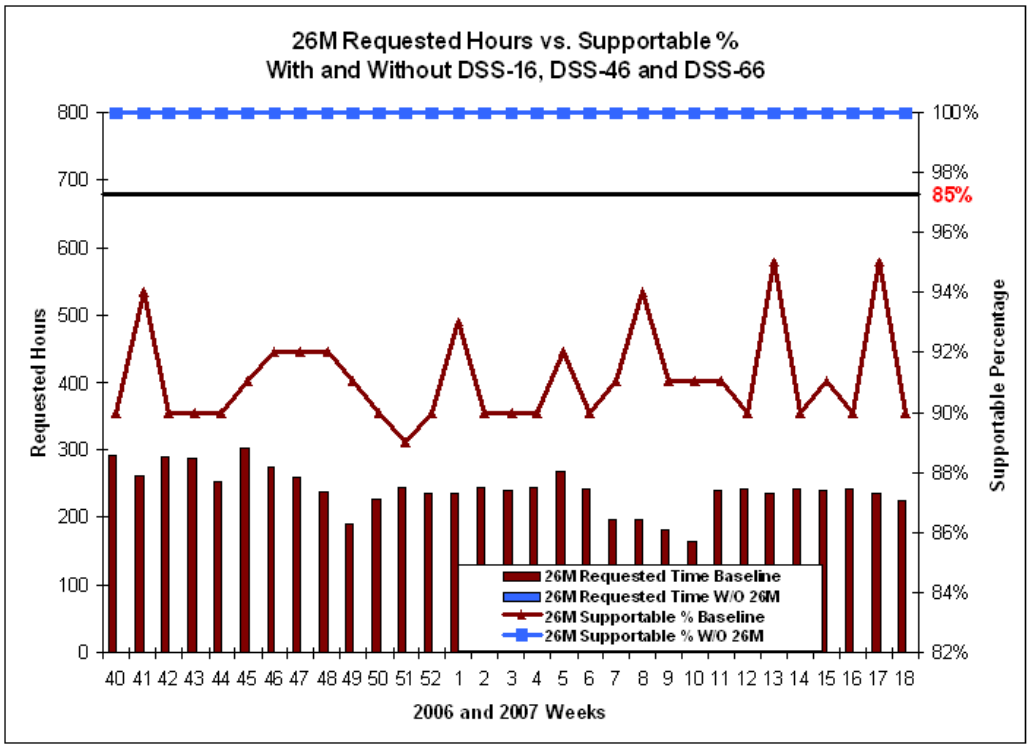


Figure 20: DSN Major Events and downtimes for 2005

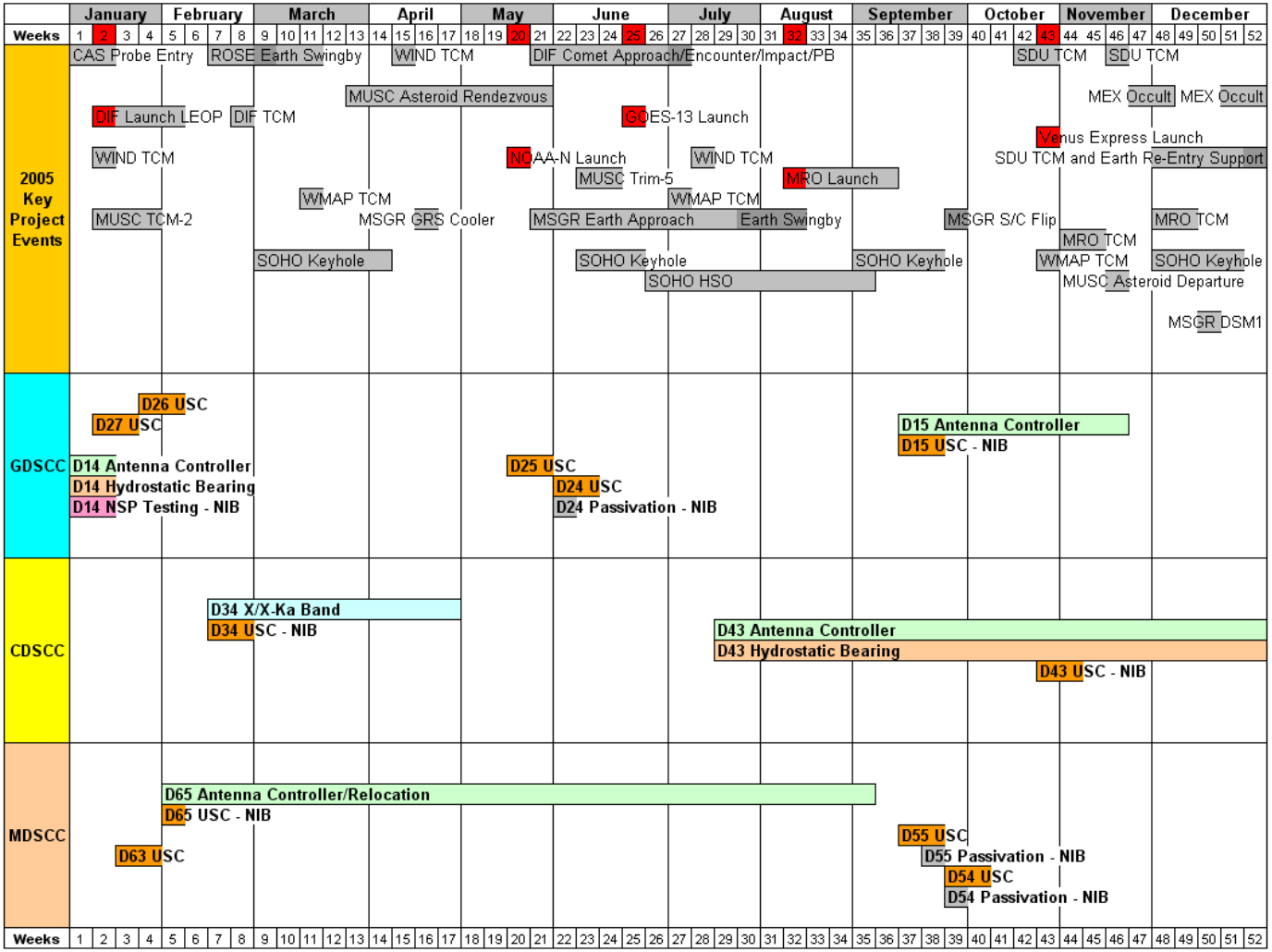


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Figure 21: DSN Major Events and downtimes for 2006

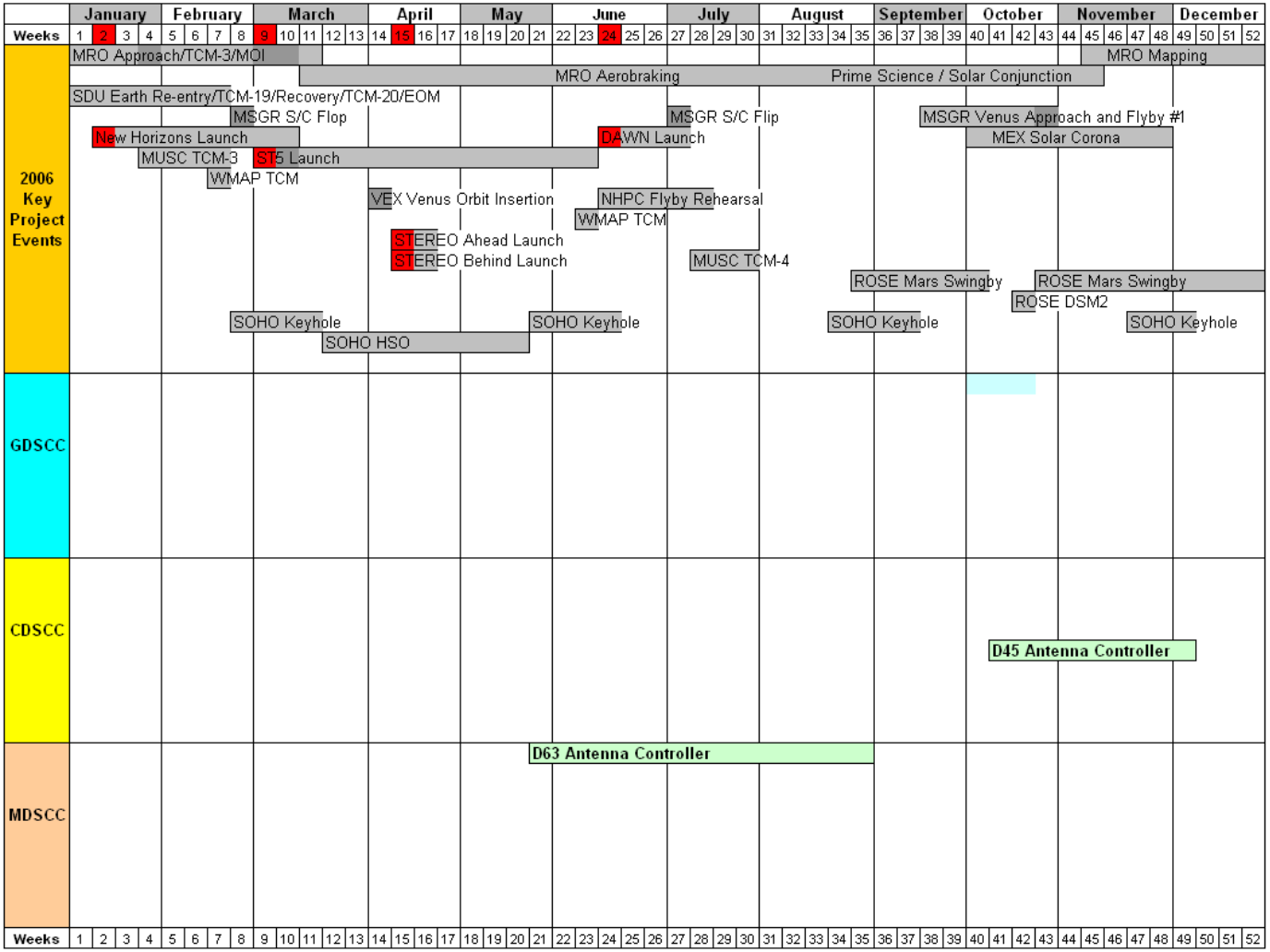


Figure 22: DSN Major Events and downtimes for 2007

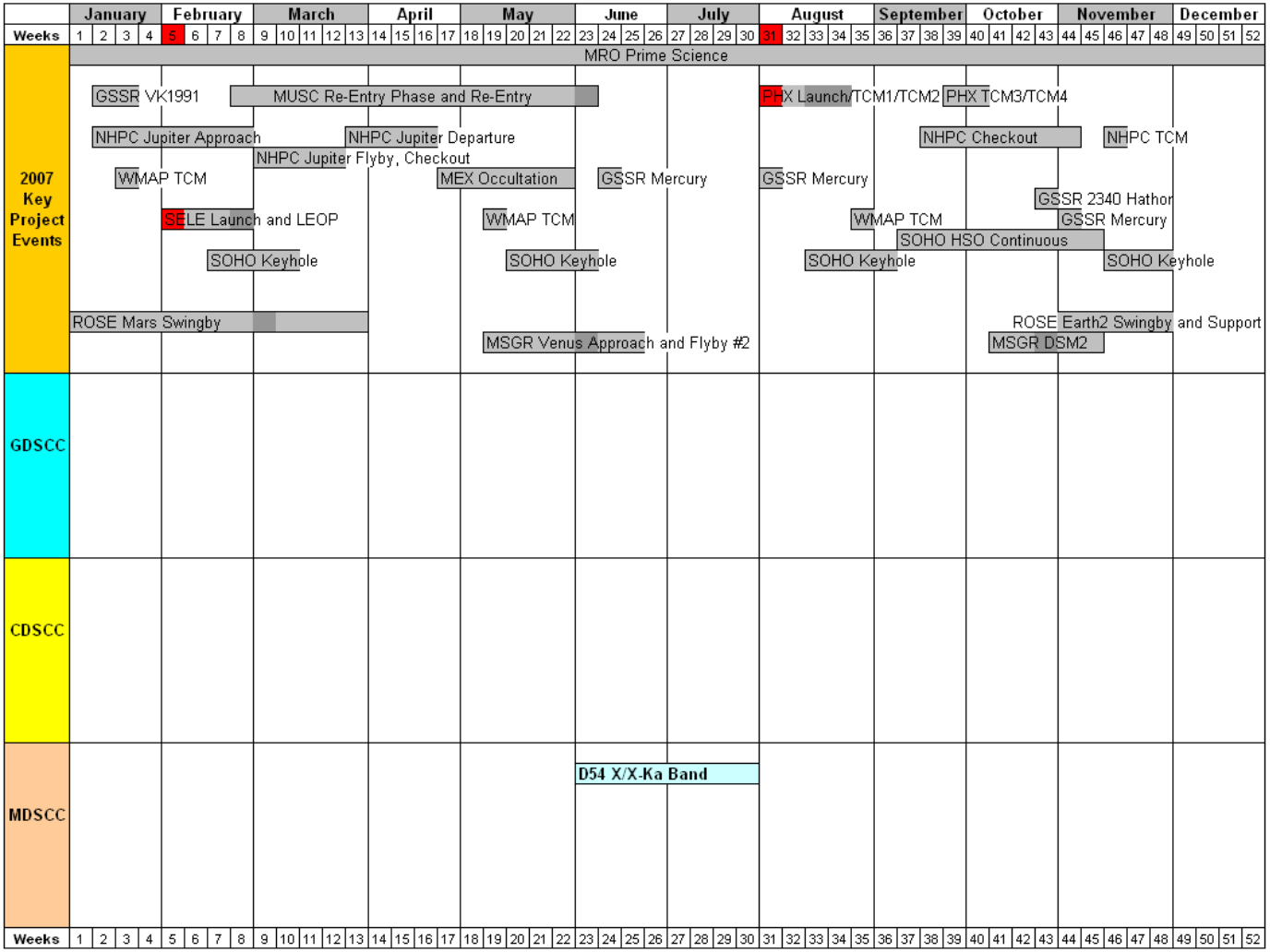
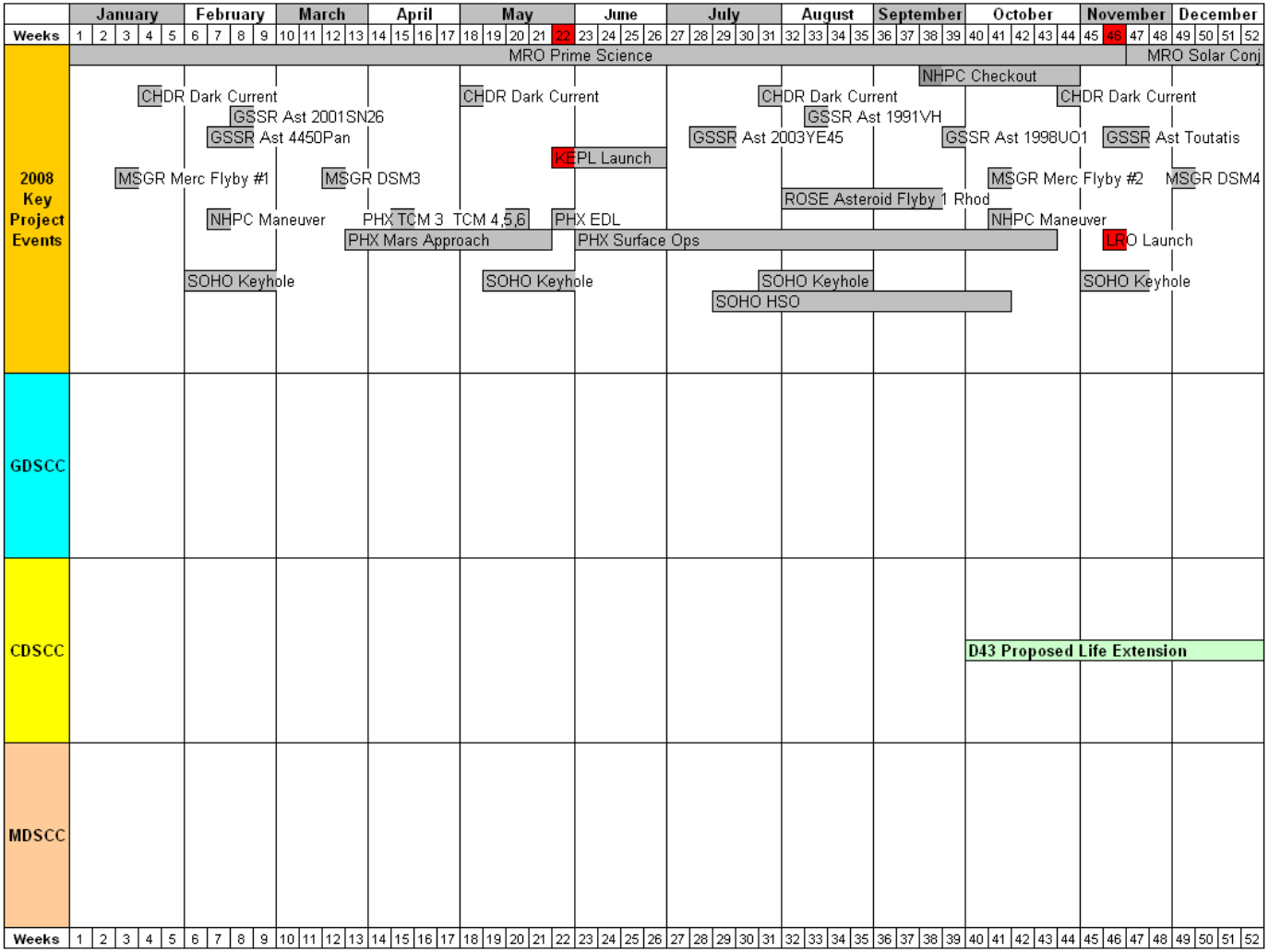


Figure 23: DSN Major Events and downtimes for 2008



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